Hocart (J. H.)

ANTISEPTION.

Chemical Agency directed against the Source of

SEWER GAS.

ANTISEPTION.

CHEMICAL AGENCY DIRECTED AGAINST THE SOURCE OF

SEWER-GAS;

ILLUSTRATING WHY MECHANICAL AGENCY ALONE DOES NOT PREVENT THE VITIATION OF HOUSE AIR BY SEWER-GAS, AND WHY THE GERMICIDAL ACTION OF CHLORIDE OF ZINC HAS BEEN RESORTED TO AS AN AUXILIARY TO THE WATER-CARRIAGE SYSTEM,

BY J. HAMELIN HOCART, B. A., B. SC.

ALSO,

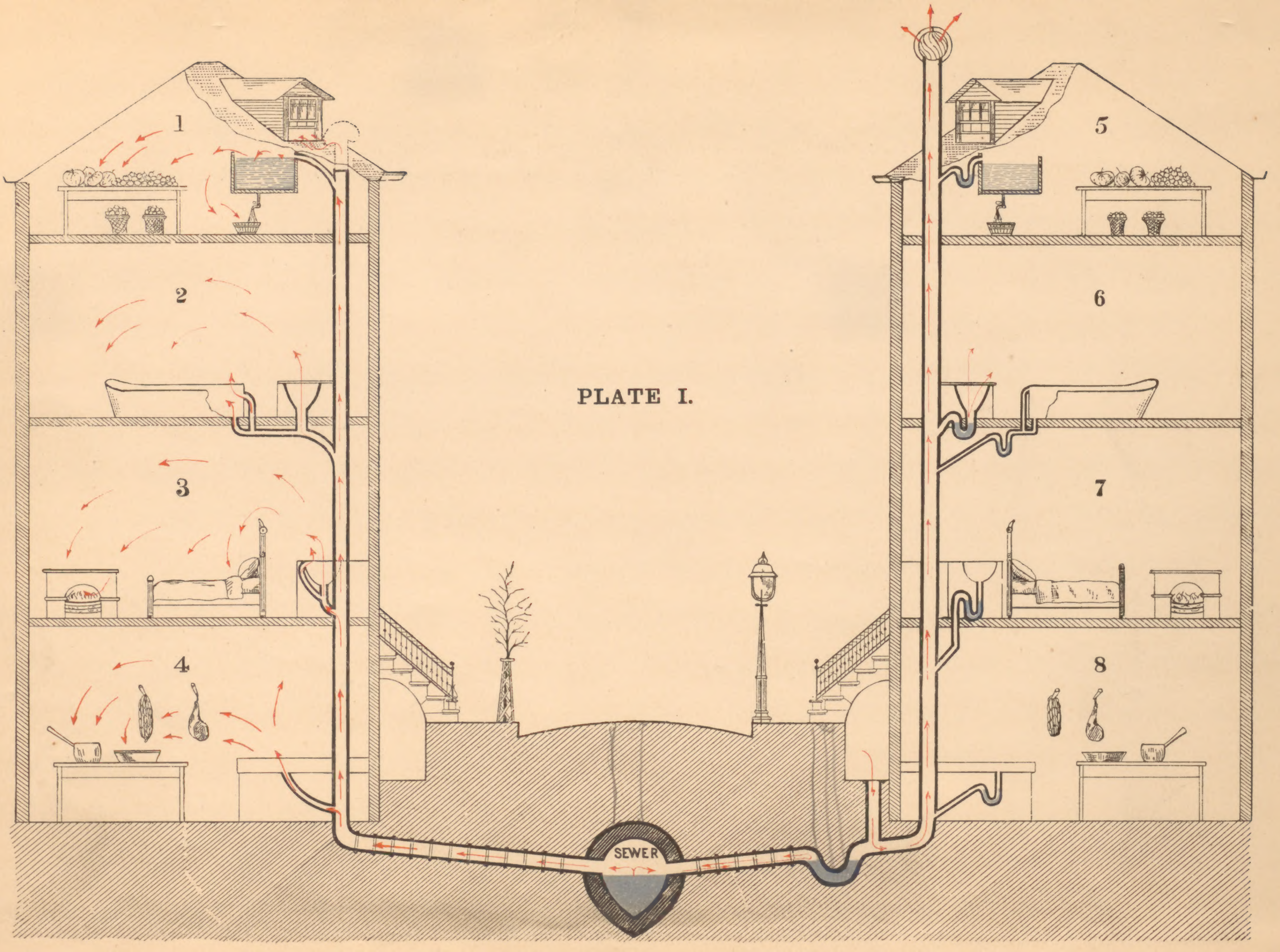
A PAPER RELATING TO A NEW METHOD FOR THE PRODUCTION OF CHLORIDE OF ZINC FOR THE GERMICIDE,

Read before the New York Academy of Sciences, Dec. 13, 1880,

BY

H. A. MOTT, JR., PH. D., F. C. S.

PLATE I.



Mechanical Defecation of Drains.

(Cleansing Drains by Water and Air.)

SEE PLATE I.

HOUSE IMPROPERLY DRAINED.

The red darts show the course sewer-gas may take.

In room 4 — a kitchen — sewer-gas is seen to enter through the untrapped sink waste-pipe, impregnating meat, milk, etc., causing them to readily spoil.

In room 3 — a bedroom — sewer-gas may bring its power to disease through the untrapped wash-bowl waste-pipe, by passing over a bed. The dart over the fire recalls the fact that foul air may be drawn into a badly ventilated room from waste-pipes.

In room 2 — a bath-room — the entrance of gas and bad odors is shown in the basin, bath-tub waste-pipe, and overflow.

In room 1 — the top floor — foul air is again seen to enter through the untrapped overflow of a water-tank, rendering such water unfit for drinking or cooking purposes.

The open window is seen to receive foul air from a low ventilator (shown by dotted lines), attached to a soil-pipe.

HOUSE WITH DRAINS TRAPPED & VENTILATED.

The imperfect drainage of the opposite house is here corrected.

A trap in the soil-pipe before it enters the sewer presents a barrier to the entrance of sewer-gas. The trapping water being represented by the blue coloring.

The air-inlet shaft under the front stoop permits a current of fresh air to enter the soil-pipe and by passing through it and out of the high ventilator on the roof, an air defecation is effected. Fresh air instead of sewer-gas thus ventilates the stand or or soil-pipe.

Each room is seen to be guarded against the entrance of foul air by traps in the waste-pipes.

The water closet — room 6 — is seen however still to receive foul air, as indicated by the darts.

This is owing to the fact that although the air within the soil-pipe is free from sewer-air, still it is not sufficiently purifiied, but that on passing through the trapping-water by ABSORPTION, it may become manifest.

The trap and receiver within the water closet may become foul, and thus a small cesspool is formed which may continually evolve impure air.

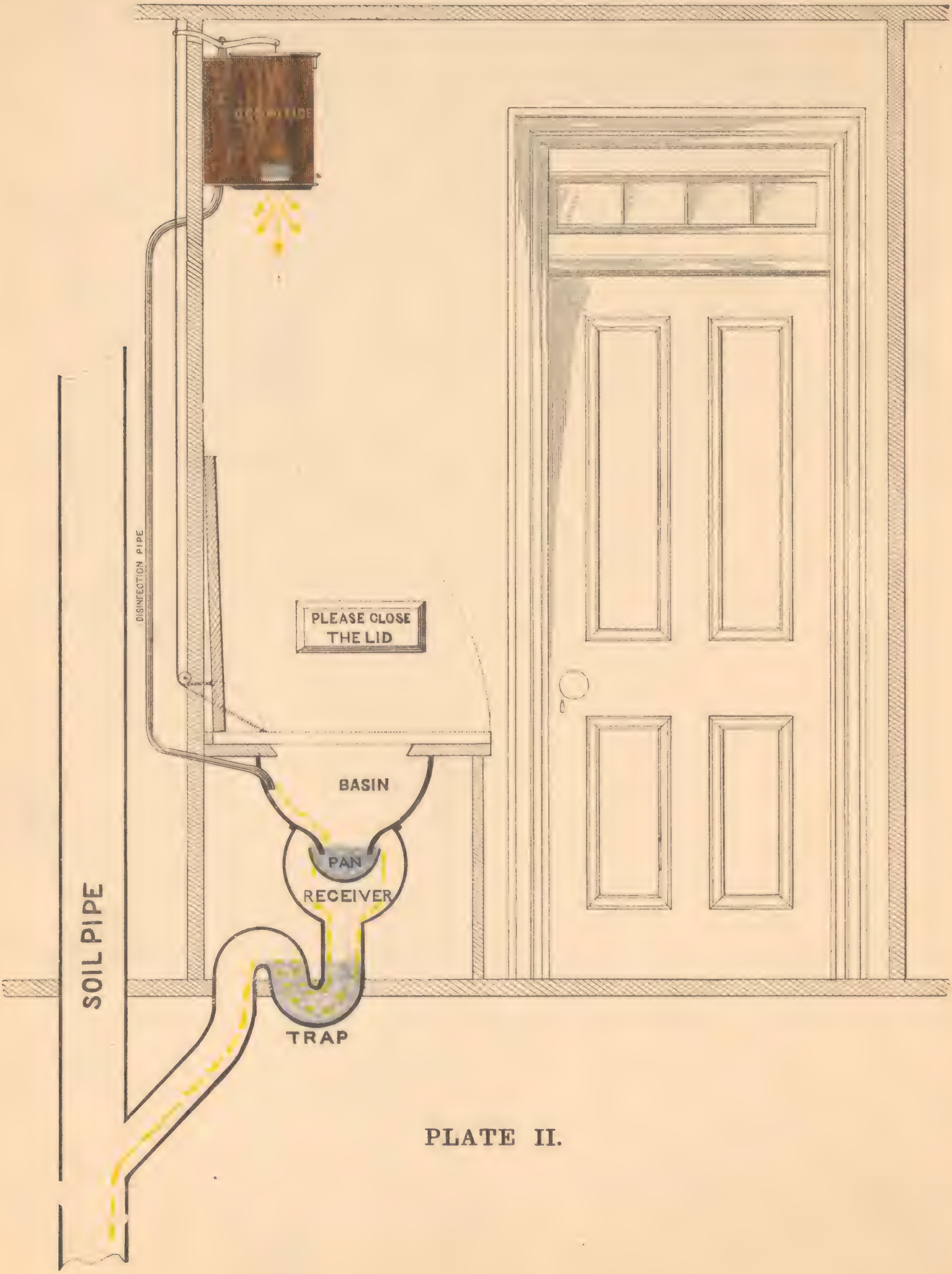

DISINFECTION PIPE
PLEASE CLOSE
THE LID
BASIN
PAN
RECEIVER
SOIL PIPE
TRAP

PLATE II.

Chemical Defecation of Drains.

(Purifying Drains by Chemical Agency.)

SEE PLATE II.

A properly constructed W. Closet may be unhealthy or disagreeable from the following causes:

I.—The water in the trap permits the harmless gases of sewer air, possessing odor, to pass through by absorption, and the dangerous but inodorous disease-germs to effect a passage by the occasional agitation of trapping water.

II.—The trap and soil-pipe are local depositories of decomposing material.

III.—Traps get emptied of their contents by evaporation and sewer-suction, thus permitting free ingress of sewer-gas. The opposite plate shows a GERMICIDE (germ-killer) above the seat, into which a supply of chloride of zinc, in a solid form, is placed once a month. Water constantly enters the apparatus, and causes a continual dropping of dissolved chloride of zinc to enter the pan, as shown by the yellow drops.

The effort of raising the lid on entering the closet causes an invisible but highly antiseptic vapor of Thymol to issue from the GERMICIDE, as shown by the yellow darts.

The constant flow of chloride of zinc prevents the decomposition of house-waste until after it reaches the sewer, it impregnates the water in the trap by an antiseptic, which prevents the hurtful constituents of sewer-gas from passing through the trap, and the constant dropping prevents a trap from remaining empty.

The Thymol vapor mingles with the air of the closet during its use, and destroys the harmless but disagreeable gases that may pass through the trap.

PREFACE.

The object of this monograph is to show what are the possibilities of the art of plumbing with reference to domestic sanitation, and to attempt to show why mechanical appliances, unaccompanied by chemical agency, are insufficient to insure health in homes.

The theoretical considerations and deductions briefly referred to in this preface are addressed more particularly to the medical profession, sanitarians, and others interested in preventive medicine.

To popularize the use of antiseption as a sanitary precaution within our dwellings, low cost of material used, together with a recognized efficiency, are essential.

Whatever is considered to be the effect of an antiseptic upon disease germs, whether it is a catalytic action or coagulation of albumen, etc., etc., the action is referable to that existing between one or more molecules of the disinfecting material upon the physical nucleus of disease termed a morbid bioplast, or disease germ.

As contagion is not a gaseous or vapory emanation, but consists physically of minute solid particles, not subject to definite laws of diffusion, but capable of existing in large or small numbers in any given space of air, it is obvious that intensity of infection is in a direct ratio to the number of germs existing in the air that a person may inhale.

If but one germ should be floating in a room, the *chances* of infection would be just one hundred times less than if a hundred germs existed within the same space, providing the persons entering were equally susceptible to contagion, "or in other words, double the number of germs and you double the danger; diminish the size of the room by one-half and you do the same." The same holds good whether disease germs are diffused in air or water; and if we consider an aerial or a liquid antiseptic to be composed of physical points called molecules, and that the action of an antiseptic, or any form of matter, is merely the aggregate action of its molecules, it follows that the more molecules there are present in any space, the greater are the *chances* that an antiseptic molecule will come in contact with a disease germ. Again, if we consider any putrescible substance, before putrescence has actually been incited, as merely a nidus, or favorable place for the growth and increase, not of innate germs, but of germs floating in the ambient air, it is obvious that the actual amount of any antiseptic necessary to prevent putrescence must always be variable, and, aside from its colytic qualities, must be present in variable quantity to overcome the varying germ action of the atmosphere.

Therefore, experiments cannot indicate to what degree of attenuation an antiseptic can be subjected to, unless the actual number of disease germs which may chance to come

in contact with it from the surrounding air is known. As this cannot be ascertained, it follows that the power of an antiseptic is necessarily variable, and its degree of attenuation compatible with its power to prevent putrescence is at all times contingent on the particular number of germs the surrounding air or water may contain at any particular time.

In the antiseptic action of chemicals upon excreta passing through house drains, where a *temporary* action is alone demanded, no theoretical considerations can lead us to predict just how much of any given antiseptic would be required to prevent initiative fermentation. The most that can be done is to use that quantity which actual practice shows to be sufficient in each particular case.

An aerial *disinfectant* employed to stamp out *large numbers* of disease germs, experience seems to show must be used in such quantities as to be hurtful to animal life. An aerial *antiseptic*, however, employed to render the air unfavorable to the increase of many germs from a few, lessens the *chances* of infection, because it prevents the increase of germs numerically in any particular space, besides rendering the air unfavorable to the existence of those already developed.

The use, then, of aerial antiseptics is not only rational, but demanded in air spaces continually exposed to the entrance of germs.

If, as an aerial antiseptic, one is used not possessing a strong or irritating odor, the additional advantage of maintaining closet air unfavorable to germ life without masking the odor of effluvia by a more powerful one, seems to be realized.

Antiseptics should in no case be employed when radical imperfections or defective plumbing cause house drains to imperil health. Mechanical perfection, however, in the construction and ventilation of drains, traps, etc., has in practice shown that gases from the sewer, as also those generated within the house drains and traps, whether very slightly or very strongly odorous, are not excluded from the house by the present state of the art of plumbing.

The absorption of air or gas by water in traps, the emptying of traps by siphonage or evaporation, the fact that traps, receivers, angles, etc., by collecting and retaining fæcal matter, cause the generation of impure air within the house, produce results not as yet overcome by the mechanical defecation of house drains.

As an adjunct to the best and average plumbing and ventilation of soil-pipes, and only in the absence of serious defects, should antiseptics be considered as essential to the water carriage system.

Careful experiments, extending over a series of months, in many hundred different localities in this city, where the best and the worst plumbing existed, has shown that in all cases where a water-closet existed sewer gas was more or less dominant, and that in every such instance gratifying results were produced by the combined action of *intermittent* aerial and *continuous* liquid antiseption.

As the drainage system necessarily creates local cesspools within the house, antiseption is consequently as applicable to the water system as to the privy vault system, with this material difference, however, that in the privy vault system the object is to actually disinfect large masses of material in which fermentation may have already existed for some time, while in antiseption a totally different object is to be obtained, namely an *antiseptic or preventive action.*

The reason why continuous antiseption has given under widely different circumstances such a uniform result is because it does not alone supply the drains occasionally with a large amount of disinfecting material which would only remain temporarily within the drains, but it causes a constant stream to exert a preventive or antiseptic action on any morbid bioplasm which might exist within the air or water of drains.

The antiseptics used in the appliance which has been named a "Germicide" or germ-killer, and which is pictured in Plate II., are chloride of zinc and thymol.

The former, called when dissolved in water Burnett's Disinfecting Fluid, is so well known to possess the required properties that further concurrent testimony seems superfluous.

As an aerial antiseptic or mild disinfectant thymol is an appropriate substance, owing to its freedom from a strong and overpowering odor, which, like that of carbolic acid, so predominates over other milder effluvia, that we may be left in doubt as to whether the odor is really extinguished or merely compounded with that of carbolic acid.

If a powerful disinfectant is to be used, then sulphurous acid, chlorine, etc., must be employed in sufficient quantity to render the air irrespirable; but when a mild antiseptic action is demanded in circumscribed air-spaces, then the material employed should not have of itself sufficient odor that by any chance it could mask the real odor we seek to destroy, but by combining with actually destroy all strong odor. If a strong-smelling aerial disinfectant is employed as the unwashed sometimes use perfume, no real sanitary results are likely to accrue.

Some interesting experiments made in New Orleans during the yellow fever epidemic, from September 9th to November 24th, by Mr. Van Slootin, have shown a relation to exist between the contagiousness of disease and the actual amount of albuminoid ammonia in the air, the latter being considered the ponderable and essential form of matter accompanying disease-germ life. He found that when yellow fever was at its height 1,000,000 cubic feet of air contained 400.75 grains of albuminoid ammonia, and that as the epidemic declined the amount of such ammonia also declined in quantity, until when the epidemic had expended its fury the amount decreased to 47.25 grains.

As aerial antiseption, as employed by the Germicide, is not intended to stamp out large numbers of disease-germs, as would be the desired result during an epidemic, but merely to maintain the air of a closet unfavorable to germ life, a proportionately smaller amount of antiseptic material is required. Assuming, however, that in every 1,000 cubic feet of closet air 4,007 grains of albuminoid ammonia existed, the quantity proportionately found in 1,000,000 cubic feet of air during the said epidemic, and that an equal weight of thymol would be required to counteract the contagious action of such air, then if 4 grains of thymol are volatilized in every closet 10 feet square and 10 feet high, and, therefore, containing just 1,000 cubic feet of air, it would appear from theoretical considerations that a sufficiency was used. In actual practice, however, the Germicide vaporizes about 12 grains of thymol during each twenty-four hours, equal to 360 grains in a month, or three times as much thymol as theory would indicate as necessary for an air rendered as unhealthy as a raging epidemic could make it. In addition to thymol vapor there issues from the Germicide 2,400 grains of alcohol every thirty days, or an average of 80 grains per diem of a powerful antiseptic added to that of the thymol. It must appear, therefore, from theoretical considerations, that a superabundant antiseptic action is maintained within the closet.

Although the amount of either aerial or liquid disinfectant actually required in practice can only be determined by the actual experience already resulting from the use of the Germicide, still the above considerations suggest that in dealing with disease matter floating in the air, and with volative antiseptics, highly attenuated forms of matter with subtle properties, and in almost imponderable quantities, are the main elements of this sanitary problem. In this regard the action of antiseptics is by some considered to be almost independent of their quantity, the action being referred to one of *mere presence*, synonymously known as that of catalysis.

The features of the Germicide system, then, can be summarized as follows:

1. It prevents the fermentation of excreta until they have reached the sewer.

2. It maintains within the closets an atmosphere unfavorable to the existence of disease, not by *odorizing*, but by an *actual* antiseptic action, and destroys the gases which possess odor, and which may pass through the trap.

3. It impregnates the water in traps by a metallic chloride, thus preventing the passage of inodorous but dangerous constituents of sewer gas.

4. It prevents traps from emptying by suction or evaporation.

It performs all of the above without reliance on the attention or caprice of anybody, but under the guidance of the systematic and competent attendance of an inspector, who visits each house *once every month*.

THE NATURE OF SEWER GAS.

Sewer gas, a potent medium by which the germs of contagious disease are carried into the atmosphere of dwellings, may be considered:

I. As composed of gases which offend the sense of smell, but which are harmless in themselves.

II. And microscopic entities, unequally diffused throughout sewer air, destitute of smell, but possessing the power to reproduce disease when brought within the fertilizing agencies of the animal economy.

This dual character of the emanations arising from the putrid fermentation of excrementitious material—the one, harmless *foul odor*, the other virulous nuclei destitute of smell—would appear to be a wise provision of nature by which the presence of the hurtful constituents of sewer gas are made manifest by the odor of their environing and wafting medium.

Apparently, nature, in thus conferring upon sewer air that quality of warning us of its presence by an appeal to our organs of smell, has hung out a danger-flag as a signal that we may escape. The falsity of this conclusion, however, has so greatly impeded the prevention of disease from the source in question, that for years an unjustifiable stagnation in domestic sanitary progress has resulted.

Sewer gas may be so unbearable to the sense of smell, its fetidness may be so nauseating, as to cause even great discomfort to sensitive persons, and yet be powerless to produce disease. Conversely, the entrance of sewer air into dwellings may continue unnoticed for indefinite periods, entirely unappreciable by those daily breathing the confined air of houses and still be potent to harm.

A philosophical recognition of the condition in which the bacteroidal organisms, nuclei, or germs of disease (which are mere physical points) exist within the so-called sewer gas, at once establishes the evidence of the reason why sewer gas may or may not be hurtful to health.

The laws of diffusion governing gases compel all the gaseous constituents of sewer air to be uniformly mixed, thus producing a homogeneity of composition. The solid, dust-form germs, however (unlike the chemical molecules of a gas), are dispersed within a given quantity of sewer air and obey the laws of gravity and are not controlled by diffusion; it is apparent, therefore, that whether one or more germs are present within a

confined amount of sewer air, is a mere matter of chance; there might be in a cubic foot of sewer air a thousand germs, or one germ, or none at all. These germs, mote-like, dust-forms of matter, obey the laws of gravitation and subside within an air absolutely at rest, but are susceptible to a dislodgement from any surface upon the merest impulse imparted to them.

The fallibility of the assumption that the presence of odor is the index from which to judge as to whether we are safe from the contagious influences of sewer air, cannot but be apparent, and we must not fail to distinguish between the mere chemical poisoning property of the odorous gases of sewer air when breathed in enormous volumes, and which only hurt by instant contact and in direct proportion to palpable and ponderable dose, and the morbific ferments or contagia which have their essence in living, self-multiplying organisms and which are factors of the etiology of contagious disease.

In sewer gas generated within the soil-pipes of houses by the fermentation of excreta before it is carried to the sewer, we have only in a less degree the essential elements that characterize the properties of street sewer gas.

In considering, therefore, the means to be employed to protect health in houses this domestic source of sewer gas must be considered as no less important than the importation of gas into dwellings from the main sewer.

The question now arises, are the means now adopted efficient in not only preventing the domestic generation of sewer gas, but also in acting as a complete barrier to its entrance into dwellings from the main sewer. So far as the domestic generation of sewer gas is concerned no preventive measures are adopted, except the transporting agency of water carriage (ventilation of soil-pipes in no sense prevents decomposition, nor does it disperse contagious air with sufficient alacrity). The fact, however, is that the volume of water actually used to convey voided material to the sewer is not sufficient to lodge it under the street before incipient decomposition sets in.

The other equally important fact to be recognized is, that owing to bends, angles, rough surfaces, etc., of house-drains, an accumulation of fermenting matter always exists which is not dislodged by the flow of water through the drains. These internal sources of gas generation, added to the source existing outside of the house, confer upon the question of the suppression of sewer gas more complexity than is usually recognized. It must be evident that the mechanical agency of water must be supplemented by some power which shall confer upon house waste the property of withstanding decomposition and the elimination of gases until transported beyond the domain of house drains, and it is equally evident that this power can only be conferred upon house waste by an antiseptic material which shall temporarily prevent such decomposition.

Now at the outset the well-defined difference between the action of disinfection and that of antiseption must be clearly distinguished. The addition of chemical substances to organic matter for the purpose of overcoming putrid fermentation, habitually used only after such fermentation has revealed itself by its characteristic fetid odor, is a useless

practice when applied in domestic sanitation. The addition, however, of a small amount of any particular antiseptic to house waste before decomposition has set in and before house waste has, by such decomposition, become what is commonly known as sewage, is an entirely different process from that of using large amounts of disinfecting substances upon organic matter after decomposition is in active operation. Concerning the latter familiar custom, no better commentary on its value is necessary than to be reminded of what it has *not* achieved in domestic sanitation.

If the treatment of excreta within house drains is deferred until we are reminded by fetid odor that decomposition has set in, the mischief, so far as that is implied, by the generation of gases and the multiplication of disease producing germs, is already accomplished. The fact that the proper time to employ chemical action is not when the senses are awakened by odor or the human system is attacked by disease, but long before these results obtained, cannot be too urgently presented.

The fact that a necessarily large amount of any disinfectant must be employed in order to overcome active fermentation, an infinitely greater amount than if employed antiseptically, renders, owing to the cost, the use of disinfectants for house drains prohibitory.

As an opinion prevails even among some sanitarians that by the ventilation of soil-pipes complete immunity is secured against the evil consequences of sewer gas, the cause of the false security created by such an opinion should be explained. Ventilation implies a constantly changing current of air caused by draft; if, therefore, no ascensional impetus is imparted to the column of air within a soil-pipe which terminates with open extremity above the roof no change of such air is produced. The discussion, almost carried on *ad nauseum*, between the advocates of a trap between the soil-pipe and the sewer and those opposed to such an arrangement, illustrates how opinions of men become warped and entangled when endeavoring to produce an effect by an impossible cause. The fact being recognized that traps do not prevent the ingress of sewer gas, the difficulty instead of being obviated has been complicated by the use of an infinite variety of so-called "systems," all aiming to accomplish the desired end, but in reality rarely doing more than mitigating the evil.

Without referring to any of the really worthless devices for the ventilation of soil-pipes, the initiative step of real improvement with its progressive accessions is alone worthy of notice. When it first became generally recognized that the air within house drains was really carrying its pollution through the water of traps, the almost instinctive idea of opening the upper extremity of a soil-pipe to the free access of fresh air was conceived of. This plan was accomplished by continuing the soil-pipe up through the house and above the roof. The effect of this uncorking of sewer air and dissipating it above house-tops, merely, in many cases, to be returned to the lungs of those residing in the upper stories of houses, is too palpably vicious to long survive an existence. To permit a dwelling, to allow by an open connection with the street sewer a mere extension of the

same to ramify throughout its internal structure, permitting through the existence of leaky joints in the soil-pipe, avenues for the entrance of sewer gas, evidently suggested the use of a trap at a point where the soil-pipe enters the sewer. The existence of such a trap, however, while evidently preventing any entrance of sewer air except by absorption through the trapping water, defeats entirely the possibility of causing a current of air to ascend through the soil-pipes, because it becomes in all respects like a chimney with its lower end bricked up. Which shall it be then, an open soil-pipe blowing up sewer gas from the street, and thus really ventilating the street's sewer at the expense of householders, or an open soil-pipe blocked up by a trap, which, in reality, does not accomplish anything. To permit of a current of air to ascend through the soil-pipe, and at the same time make use of a trap, requires that an air inlet should exist between the house and such a trap. By such an arrangement direct communication with the sewer is cut off, without blocking up the lower extremity of the soil. In plate 1, the house on the right hand side is provided with such an air inlet as represented.

The question is often asked, how can disease germs get into dwellings, without producing odor, if their carrying medium is sewer gas, which of itself possesses odor? It must be remembered that one of the incomprehensible things of nature is the potentiality of infinitely small physical points of matter, like germs, so small as to be almost invisible under our highest magnifying powers, so potential as to multiply from one to sixty millions in twenty-four hours. This potentiality can be compared to the power of one spark of fire to wrap a whole city in flames. When we speak of germs, we talk of a thing we know nothing about, except that it is power embodied in littleness. For all purposes of multiplying within our system, one germ is as sufficient as the contact with ourselves of a hundred.

To a powder magazine, a spark is as fatal as would be a volcano. In guarding our lives against virulous invisibility, we must dispel the idea of tangible poison and realize tho ethereal, subtle, dormant atom, capable almost of insinuating itself between the very inter-molecular spaces of matter.

Sewer air can be so diluted that the sense of smell no longer reveals it to our presence, but the poison-spark that inflames us with disease is beyond attenuation, the germ may be present, it may be wafted by fetid air diluted beyond recognition. Thus it is that odor serves as no signal of danger, no telltale of existing peril. It is really easier to conceive of the passage of these mote-like forms of matter through the water of traps than to comprehend just how the molecule of a gas can pass between the molecules of water. The process known as the absorption of gases by liquid. This absorption of sewer gas by water, is like the absorption of carbonic acid in our familiar drink of soda-water. Can we not much more readily explain how a little particle of dust could fall upon the surface of our glass of soda-water and by gravitation gently subside to the bottom of the tumbler, than to conceive of how a molecule of carbonic acid can remain

entangled between the molecules of water. And yet we hear it said, that while the sewer gas can pass through trapping water, germs cannot. Germs are not absorbed by water, they do not diffuse like a gas, they gravitate and fall upon the surface of the water in a trap, and providing such water remains at rest, these germs cannot disregard gravitation and pass up to the surface of the water as would a gas. Their physical infiniteness and lightness confer upon them such mobility, however, that the merest agitation impels them impulsively to mingle with the water, and by the many causes that tend to turmoil the water of traps even to its frequent expulsion, these motes become liberated.

The capacity of germ-like matter to remain commingled with water, illustrating its perfect miscibility with this fluid, is demonstrated by the turbidity of fertilizing solutions after impregnation.

As sewer gas possesses dual properties, one capable only of annoying the sense of smell, the other of impregnating us with the seeds of disease—it is evident that a corresponding twofold agency must be employed for the complete suppression of both.

It will be seen after an investigation into the action of the Germicide, that the continuous flow of chloride of zinc, which delays the decomposition of house waste, and destroys living germs which might pass through the water of the trap, and the neutralization of odor caused by the use of thymol, confers upon this double application of antiseptics a well-devised action, which in practice perfectly fulfills the desired requirements.

Mechanical Defecation

of

House Drains.

BEFORE attempting to describe what is proposed for the sanitary amelioration of dwellings by the *Germicide System*, (see plate II) it will be shown why it is necessary to do anything more than is *already* advocated by some sanitary authorities.

As upon the speedy and thorough voiding of excreta depends the health of the body, so does the rapid cleansing of the soil pipe and sewer influence the sanitary condition of the house and city. So much has already been written concerning infectious diseases, referring their origin to emanations of accumulated impurities, that mere allusion to the subject will be sufficient in this instance. There is no lack of information concerning the relations of diet, exercise, etc., to health, but it is surprising that comparatively little attention has until lately been bestowed upon the equally important study—how to render our houses healthy by removing those evils which, we are now beginning to discover, manifest themselves in the development of zymotic diseases and the minor afflictions of headache, loss of appetite, debility, and the general lowering of the physical tone. It is not too much to assert that one-half of the sickness and premature mortality in families of large cities is the result of defective drainage.

Aided by those improvements which mechanical ingenuity, guided by a just appreciation of sanitary requirements, has placed within our reach, the present generation has come to enjoy greater immunity from disease than its forefathers. Pests and plagues are becoming almost traditional. Especially in England, where sanitary appliances are so much more perfect than with us, is noticeable the great advance.

If, then, premature mortality is to a great extent within our control, and if one element of its decrease in large towns is the adoption of more perfect systems of house drainage, the subject becomes one of grave importance.

The two chief objects of a perfect system of house drainage should be:

I. The immediate and complete removal from the house of all foul and effete matter directly it is produced.

II. The prevention of any back current of foul air (sewer gas) into the house through the conduits which are removing the foul matter, etc.

The first object, namely, the removal of foul matter, we attempt to fulfill by water-carriage, as ordinarily adopted in the water-closet system. And the usual means relied on to prevent a back current of foul air from sewer or house-drain are water-traps, and air currents induced by certain forms of ventilating shafts.

It is noticed, then, that mechanical means are relied on to attain the two objects mentioned. It will be shown, however, that certain chemical problems are involved in the strict fulfillment of these two objects, and that the best directed mechanical skill, unaided by chemical agency, is inadequate.

The subject, then, of house drainage may be divided into

MECHANICAL AND *CHEMICAL* DEFECATION OF HOUSE DRAINS.

To render the chemical division of the subject more intelligible, the results obtained by mechanical means unaided will be first considered. By observing just what is being ordinarily done in our houses by mechanical agency, we will better appreciate just what is *not* done. By a representation of the house-drainage universally recognized as the most perfect, it will be shown in what consists absolute mechanical efficiency, what are its limits, and consequently what can and cannot be expected from it. It will be seen that in advocating the use of the most approved mechanical systems for the fulfillment of the objects in question, their sphere of importance is not in any degree underestimated or even subordinated to chemical agency. What will be shown, is, that no strictly mechanical system, no matter how modern or improved, can be relied on to successfully achieve the two objects we have mentioned as essential to healthy houses, unless used in connection with a chemical system equally practical and efficient.

Plate I shows a section of a house with four rooms, illustrating a system of house drainage where water is the medium for carrying the daily refuse of the house to the common sewer. The system is represented, at the left, in its simplest and most dangerous form.

The system, however, allows foul gases from the sewer to find entrance into the dwelling. In room 1, for example, the water-tank is seen to have an overflow pipe connecting directly with the soil pipe. The natural effect of this is to allow a direct inlet for sewer gas, which, passing over the surface of the water in the tank, contaminates it, and renders it absolutely dangerous for drinking purposes. The arrows show the course the gas may take, and how it may accelerate the rotting of apples, etc. In room

2, showing a bath and water-closet, the pipe from the closet basin, as also the bath overflow, are seen to pass directly to the soil pipe, opening another avenue to the street sewer. In room 3, however, the most serious consequences are experienced—those influencing the air breathed while sleeping. Here the greatest calamities to health occur, especially where there is predisposition to disease. Some surgeons, appreciating the danger to life under certain circumstances from the entrance of foul air from the water-closets or the wash basin into the bed chamber, have actually refused to perform an operation or to allow child-birth in such an apartment until proper means were adopted to prevent the ingress of sewer gas. Room 3 is represented as having a wash stand on the right and a fire-place on the left. With insufficient air entering the apartment, (say from doors and windows being closed on a cold night,) the fire in the grate, seeking its supply of oxygen from some air inlet, is liable to institute a gentle current through the soil pipe. Room 4 shows why the meat spoils and the milk sours so soon in the kitchen or pantry.

In each of these rooms it is noticeable then, that no precautions are taken to stop up the inlet through which the noxious odors from the sewer and soil pipe may enter, to the great detriment of the health of the inmates. This communication to the sewer is so free that anyone in room 2, for example, could, by putting his mouth to the overflow pipe from the tub, be heard to speak by another person in the sewer. This open channel, ramifying into other houses where perhaps infectious disease already exists, is frequently the passage along which germs of disease are carried from the sick chamber to the sleeping rooms of those in health. These openings are, however, necessary, to provide an outlet for the refuse matter of the house, to be carried by water to the sewer. Something must, therefore, be devised, which, while allowing foul water to flow away from the bath tub, wash stand, water closet, sink, etc., will not permit the inflow of sewer air.

Fortunately, by a most simple expedient, this result can be realized. It is only necessary to create, by a loop in the pipe, a sufficient place of lodgment for water, that the pipe at this point may always remain full. Such a device is called a trap, and is nothing more than a water-joint barrier to the passage of air in either direction through the pipes, which, at the same time, allows a perfect flow of water.

On the right of Plate I is represented a house in which the precaution of introducing traps has been taken. Not only are all the pipes leading into the soil pipe thus guarded, but the soil pipe itself, before connecting with the sewer, is also trapped. One of the inherent objections to traps is their liability to become emptied of their water from

various causes. *Now, if a trap becomes empty, its efficacy is destroyed.* The following simple experiment illustrates how this can occur:

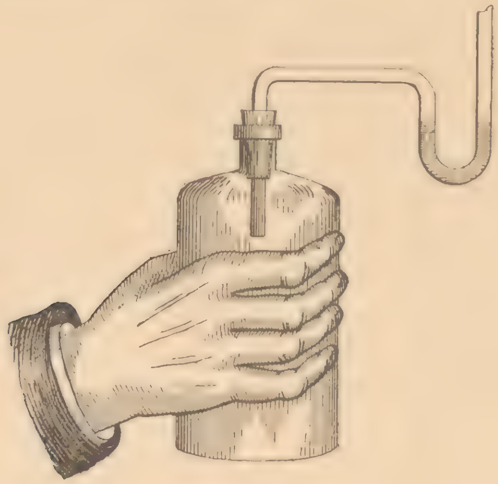


FIG. 1.

Attach a bent glass tube to a bottle, as shown in Fig. 1. Now pour water into the tube until the bend or trap is full. Now expand the air in the flask by holding it in the warm hand, and the water in the trap will be forced out and issue from the top of the tube. If, while the air in the flask is still warm, the trap is again filled, the water will be sucked into the flask as the air cools. This force and suction process is imitated on a powerful scale by the street sewer, which bears the same relation to the pipe traps of dwellings that the bottle bears to the bent tube.

There are various reasons why the sewer has the power of thus emptying traps. After a heavy rainfall, for example, when it is carrying an unusual amount of water, the free space above the usual water level is diminished, and then the air, becoming compressed, can exert sufficient pressure to force out the water from the soil pipe or house traps. Again, sewers emptying into tide rivers (as in this city,) allow the water to creep up further into them at high than at low tide, and pressure on the traps again results. The gases generated within the sewer from decomposing organic matter, also exert an expanding action, just as gases from the stomach produce eructations. As the sewer runs empty of its surplus rain, as the tide ebbs, etc., the pressure, diminishing, establishes a suction action on the traps, and they are then liable to be emptied in the reverse direc tion, i. e., sucked dry. The remedy, then, of introducing traps as barriers against the entrance of sewer gas, is still incomplete.

The next step in advance allows the soil pipe to be open at its highest point, extending it above the roof. The dotted lines represent this principle in the first house. It is quite evident that no matter how hard the sewer forces air in and out of the soil pipe

no action on the traps, if any existed, is produced, because the soil pipe is open to the air above. It is obvious, however, that a soil pipe thus ventilated only prevents the traps leading into it from being emptied. The trap in the soil pipe *itself*, where it enters the sewer, can be as readily emptied as before. In this connection, then, it may be observed, that if the soil pipe trap is entirely dispensed with, the soil pipe merely becomes a chimney to the sewer, with its damper removed. This plan of allowing the sewer to gain outlet to the air above the roof of the house, created the system of *sewer ventilation*, which even now has its advocates. The system involves an attempt to prevent the emptying of traps by relieving the sewer of the pressure of foul air, drawing it up through the dwelling and dispersing it above the roof. Each house, then, becomes in itself a sewer-ventilating station. The most important objections to the plan are:

1st. It merely draws up foul air from beneath the street where it is buried, and allows it to issue again above our heads.

2d. It pre-supposes absolute perfection in the stand pipe (or soil pipe) so far as leakage is concerned.

In respect to the first objection, it must be remembered that up to a certain degree ventilation of diseased air is not a stamping out of disease-germs, but a mere dilution. Diluted virus may still possess the power to poison, and it is only when dilution is carried to a certain point that virus becomes harmless. Smallpox virus, for example, after a certain dilution still possesses the power to inoculate. A further dilution, however, renders it innocuous. The ventilation, then, of a sewer by the medium of an open soil pipe pre-supposes a mere dilution, and opens the question whether in all cases the dilution is sufficient to render the sewer air harmless. If, for example, sewer air was issuing above many houses in a block, especially in proximity to windows, the probably inefficient dilution would be manifest, especially on a wet, still night. Wind, on the other hand, would tend to disperse the foul air. The ventilator on the first house being too near the dormer window, the arrows show the course sewer gas might take. A candle flame held against a leakage in the soil pipe would frequently be blown outward, into the room, showing a current of sewer air entering the house.

This plan, if adopted, should have the soil pipe run up outside of, and not through the house. But, to quote English authority, "It is not the business of householders to ventilate public sewers; that is the affair of the authority to whom those sewers are vested. In Croydon, England, the direct connection between public sewers and the pipes which run up the sides of houses is not only dangerous to the houses, but, in relation to public sewer ventilation, the arrangement is little more than a sham."

The case, then, may be stated thus: An open soil pipe is a sewer-chimney of questionable utility; if it has a closed damper, that is, a trap at its entrance into the sewer, it ceases to act as a chimney, and if the trap is absent or empty, smoke might be

seen to enter the house, as well as to issue from the soil pipe, provided sewer gas, like smoke, was visible. On general sanitary principles the house-holder is safer not to invite the sewer and its associations about his dwelling, nor to allow his drainage to be a system of " give and take."

Having, however, demonstrated the efficiency of traps when *full* to cut off the entrance of sewer gas into our rooms, it still remains to devise a plan which, while preventing the sewer from emptying traps, does not institute a direct extension of the sewer into our houses. The radical feature of such a system of drainage is the expedient of disconnecting the soil pipe from the sewer by means of an outlet extending to the surface of the ground, between the house and the soil pipe trap. (see plate I). This principle of disconnection produces the following result: There is now a chimney running up through the house, which is being continually ventilated by *fresh* air entering the shaft in the direction of the arrows, passing up the soil-pipe, and issuing above the roof. This fresh air, constantly pouring into the base of the soil pipe, so dilutes the proportionately small amount of foul air it meets, that what *now* issues above our heads may be considered practically harmless to health.

The soil trap, lying between the air-supply shaft and the sewer, disconnects from the sewer, however, only when it is full of water. The same causes, operating to empty the soil trap still-existing, sewer air might still pass it. The final difficulty may be overcome as follows:

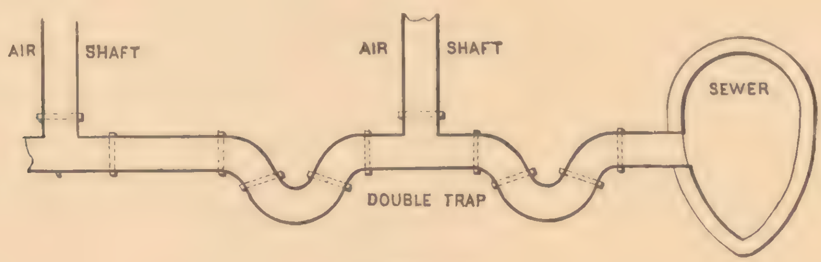


FIG. 2.

Here we have represented two soil traps and two air-shafts. If, now, the first trap is emptied by sewer-suction, the second one still remains full, and the additional air shaft allows the current up the soil-pipe to be uninterrupted.

We have now traced the subject of the *mechanical* defecation of house drains until, by improvements, we have reduced them to their minimum. The result can be epitom ised as follows:

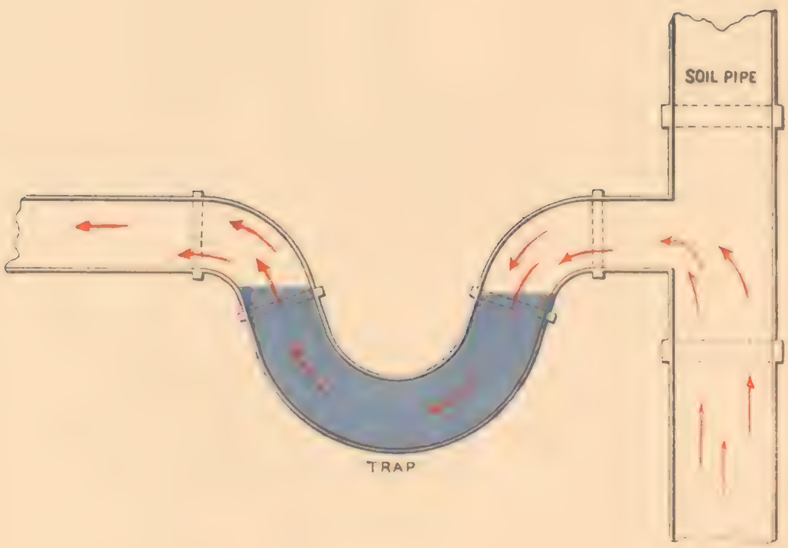


PLATE III.

SHOWING PASSAGE OF SEWER-GAS THROUGH WATER IN A TRAP, BY *ABSORPTION*.

MECHANICAL HOUSE DRAIN DEFECATION

Drains untrapped	permitting	free	entrance of sewer air.
Drains trapped without provision against syphonage,	"	occasional	" "
Drains with traps protected by air outlets,	"	no	" " " except by absorption.

The question now arises: *Does perfect mechanical defecation ensure health and comfort in homes?* The answer may be tabulated as follows:

1st, It does *not* prevent foul air passing by absorption through the water of traps in water closets.

2d. It allows traps frequently, by accumulating effete matter, to become small cesspools.

3d. It does not prevent the emptying of traps by evaporation.

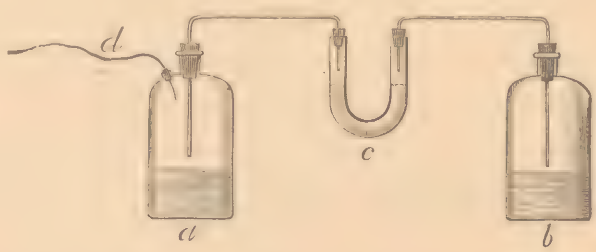
4th. It does not neutralize emanations from the person when in the water closet.

Each of these cases which mechanical defecation fails to meet, will be now considered.

1st. Passage of foul air through traps by absorption. Absorption of foul air by trapping-water is universally acknowledged by sanitary authorities. With sufficient pressure, water may be made to dissolve large volumes of gas, as, for example, carbonic-acid gas in soda water. But even in the absence of pressure the absorbing capacity of water is very great. Plate III shows a trap connected on the one side with a soil pipe, while the other is supposed to lead up to the basin of a water-closet. The arrows illustrate the course taken by the foul air. Coming in contact with the exposed surface of the trapping-water, it becomes absorbed, and diffusing itself through the water, passes through it and on up to the air of the water-closet, with which it commingles. Now, although the air of a properly ventilated soil-pipe is, as before stated, sufficiently diluted to pass out into the open air without carrying infection, it cannot be admitted that even such air could commingle with the air of the dwelling without endangering health. Much important testimony could be cited from accepted sanitary authorities on the capacity possessed by trapping-water to absorb gases. The following quotation from the By-Laws of the Uppingham Sanitary Authority, 1878, expresses the idea succinctly: "* * as regards the passage of foul gases through the water of traps *when there is no pressure.* Some sanitary engineers have hitherto been disposed to consider that this is rather a theoretical than a practical danger, and that if proper means are taken to secure water traps from pressure they

practically afford a bar against the passage of sewer gases. This is undoubtedly not the case. I have had opportunities of observing several instances of foul gases passing through the trapping-water by being absorbed on one side and given off on the other, and am convinced that this is of frequent occurrence. The passage is, however, gradual, so that if the surface of the water in the trap is freely exposed to the air, the foul gases given off from the water surface are immediately so diluted and dispersed as to be imperceptible. If, on the other hand, the water trap is in a closed pipe or drain, the foul gases which pass through the trapping-water will accumulate on the house side of the trap in sufficient volume to demand attention." Again, in 'Bayle's House-drainage' we read "Long before the point of saturation is reached it begins to give off on one side what it takes in on the other—*when* the point of saturation is reached depends somewhat upon circumstances; * * * but it is a fact within the observation of all who have studied the subject experimentally, that water exposed to contact with confined sewer-gas grows fouler and fouler, and never seems to wholly lose its capacity for absorbing until it becomes putrid, and decomposition takes place within it. In an unventilated trap a water-seal cannot remain pure for many hours. It begins to absorb at once, and the length of time required to so charge it that it will give off gases is probably, as stated by Dr. Fergus, from half an hour to two hours, according to the pressure of the gases in the pipe and their foulness. For this reason every waste pipe, even when ventilated, should have enough water passed through it daily to completely replace the seal in its trap. When the pipes are unventilated, it should be done very often.

Dr. Fergus, a most eminent sanitarian, remarks: "We are therefore very strongly inclined to believe the last alternative, namely, that however well drains may be trapped, sewer-gas will find its way from them into our houses, and any one who is acquainted with Graham's investigations as to the diffusion of gases, will readily understand how this may happen."



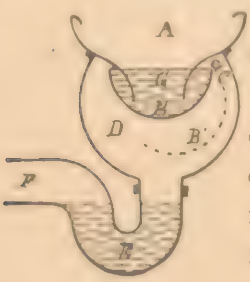
The actual passage by absorption of gases, and also of *living germs*, is admirably illustrated by the following experiment: In the fig. *a* and *b* are seen to be two bottles, connected, as shown, with a bent tube *c*. If a small quantity of some such gas as ammonia or sulphuretted hydrogen is introduced into the bottle *a*, it will not immediately pass into *b*, being prevented by the water in the bend of *c*. It will be found, however, owing to the property water has of dissolving these gases, that in a short time they can be detected in *b*,

having been absorbed by the water in the left-hand limb of the tube c, and liberated from it on the side nearest the bottle b. If, however, some material is introduced into the water contained in the miniature trap which has the power to combine with and destroy the gases coming from the bottle, these gases will be effectually arrested in their passage and will not enter the bottle b. Some nitrate of lead, for example, dissolved in the U-tube, will be seen to turn black very soon after sulphuretted hydrogen is introduced into a, entirely decomposing it as it enters the U-tube.

If air containing disease germs (and this is the important part of the experiment), such as zymotic bacteria (which are small living organisms resulting from, or, perhaps, causing, the putrefactive fermentation of dead animal matter, and the accredited cause of contagious disease in living animal matter), is introduced into the bottle a, these microscopic germs will pass, together with the air suspending them, through the water in c, and will ultimately find their way into b. Their presence is detected by introducing into b what is termed a fertilizing nidus or nest—that is, some fluid capable of supplying to these germs the conditions favorable to life. And although but a comparatively small quantity of these germs (now believed to be the "contagium vivum" of disease) pass into b, they will so multiply in their "nest" or "soil" that the solution in b will turn turbid from the presence of its swarm of moving organisms.

Again, if a "germicide" solution, or germ-killer, is put into the water of the little trap, in their passage from a to b germs will be killed in the trap, and will enter b dead and incapable of further reproduction.

2nd. Traps become cesspools.—It is obvious that the deeper the bend of a trap the more water it will hold, but the less likely it will be to become empty by evaporation or pressure. The more water-space it has, however, the more room there is for an accumulation of foul matter to obstruct the flow of water. In view of this latter a very slight seal (*i. e.* water depth) is generally advocated. Dr. Fergus believes "that it is almost impossible, even with a copious flow of water, to cause undecomposed fæces to be discharged through the bend. With any ordinary flow there is only an eddying of the water in the trap, not a sufficient movement of the whole volume to carry floating matters under the bend. 'No mere flow of water will carry out the fæces, which simply keep whirling round in it.' Often with the mistaken idea that by adding a few inches to the depth of water in the trap an effective resistance will be opposed to the pressure of sewer-gas these are made quite deep. Dr. Fergus recommends that the dip or bend should be only sufficient to secure a sealing, for the deeper it is made the more complete will be the retention of decomposing matters at the house side of the trap." Not only do water-closet traps thus become small cesspools within our houses, but the receiver of the ordinary pan-closet itself is a source of foul odor. The single "wash" of the bowl seldom carries off the whole of the last deposit, and the accumulations ferment and putrify, generating foul and disgusting odors.



We illustrate the point by a diagram in which A is the bowl, D the receiver, (called by an eminent sanitarian the "Chamber of Horrors") E the trap and F the waste-pipe. When the excreta are dumped from the pan, B, they cake and cling to the sides of the receiver and deposit a coating on its inner surface, where it is hidden from view. The water, G, in the pan interposes a seal which temporarily shuts out these vapors, pregnant with disease-germs, from the

house. When, however, the pan is dumped, taking the position of the dotted line B', a passage is not only opened directly into the room, but a gallon or more of water is thrown down, displacing so much of the air in the receiver and *forcing* it upwards. Hence the bad smell when the closet is used.

Some most ingenious forms of traps are sold which reduce all objections to their minimum, but it cannot be claimed for any trap that it overcomes *all* objections. To allow foul gases generated in traps to escape, a ventilating pipe is sometimes carried from the trap itself to the roof of the house parallel with the soil pipe. With special forms of closets where fine jets of water are allowed to escape within the receiver, or where valves are used and receivers dispensed with, some objections are diminished, but not entirely overcome.

3rd. Traps emptied by evaporation.—The unsealing of traps by pressure or suction from the sewer has been fully described, and the use of air-shafts to prevent it shown. Evaporation, however, cannot be guarded against by air-shafts. In fact, a rapid current of air through the soil-pipe increases the evaporation of trapping-water. To prevent the fouling of traps their usual form is such as to make them hold but a small quantity of water; but the more shallow the trap, the quicker it will empty by evaporation. Especially is evaporation liable to empty traps, when water-closets are only occasionally used. In warm weather a few days of disuse would be sufficient to cause the trap to become empty sufficiently to permit the passage of foul air through it. During the summer months, when families are away from city houses, the emptying of traps from this cause may, by allowing the entrance of poisoned air into the house, endanger the health of those returning fresh from the country.

4th. Emanations within the closet.—Air contamination within closets, caused by gaseous emanations from the body of the occupant, though perhaps not as yet proved to be a vehicle of contagion, even when coming from a diseased person are, however, sources of air vitiation especially distasteful to the next comer, and no attempt has been made to abate the annoyance.

Having now referred to the benefits to be derived from perfect *mechanical* defecation of house-drains, and indicated what is still unrealized, the supplementary aid of *chemical* defecation, i. e., disinfection will be considered.

Chemical Defecation

of

Drains.

MECHANICAL DEFECATION *Transports*—Chemical defecation *transforms* foul matter, and only by the judicious employment of both agents can we ever expect to realize an advance over the present results of house drainage. The transformation of foul matter into other and harmless forms by chemical agency, necessitates absolute contact of the agent employed with the matter to be changed. For example, matter in a water closet basin could not be disinfected by chloride of lime or carbolic acid kept in open vessels within the closet room. The odor rising from such effete matter might be disguised by the more overpowering odor of the lime or acid; but the source of the odor would not be reached. To deodorize is not to disinfect, except where the material giving rise to the bad odor is so changed as to become itself odorless. Deodorizing and disinfecting have been so confounded one with the other that the benefit which might be derived from the judicious use of disinfectants, is usually more than counterbalanced by the disinfectants themselves giving off so strong an odor as simply to conceal the still existing objectionable smell. While bad odor, however, is not a necessary accompaniment of diseased air, still, disagreeable odor in the water closet is a warning that should not be disregarded. Disinfection, however, is often not directed by such knowledge as renders it really subservient to the ends to be accomplished. It has frequently borne more resemblance to some function performed by savages before an idol, than to any reasonable practice of civilized men. There can be no doubt that many of the prevailing ceremonies, such as sprinkling chloride of lime in places of public resort or fumigating with carbolic acid, etc., are not only useless, but even injurious as leading to a false security. Suppose a water closet so constructed that each person after using it was required to pour a bucket of water into the basin to carry the contents off through the soil-pipe. It is quite evident that such a proceeding would be dubbed a nuisance, and water closets would fall into disuse. None would

question the power of the water to carry off the material, but would rather let the material alone than be bothered with using it. Just so with disinfection—if it cannot be applied as easily as is water, by lifting the handle in the seat, in fact, automatically, its capabilities will not be realized. The practical application of disinfection demands that a given amount of the disinfectant used shall constantly and without personal attention be brought in contact with each deposit that goes into the basin. Pouring into the basin at intervals, and only when reminded by the nose, some so-called disinfecting solution, frequently little better than colored water, is disinfection as improperly applied, as would be the bucket of water every time the closet is used.

To the improper application of disinfection can be safely attributed the varied opinion as to the merits of chemical defecation. Even a system possessing inherent good qualities must be of questionable utility if improperly applied. In our opinion, disinfection has never been properly applied to water closets, therefore its qualifications have not been practically demonstrated. Disinfection cannot become an efficient auxiliary to drainage without proper regard to certain essential conditions, namely: It must be

CONTINUOUS, AUTOMATIC, AND ECONOMICAL,

and, in fact, act by an antiseptic agency, thus rendering actual disinfection entirely unnecessary.

In the accompanying cut is seen a water-closet seat with Germicide attached above it. A concealed pipe, connecting with the water service pipes, conducts water into the vessel, which is previously filled with an appropriate antiseptic in a solid form. The water dissolves this material and then passes by another pipe into the basin below. A constant flow of chloride of zinc is thus caused to enter the basin and pass through the trap and soil-pipe to the sewer. Within the vessel is a compartment containing Thymoline, which becomes vaporized *only when the closet is visited.* Plate II. indicates a water-closet in section constantly purified by continuous antiseption, representing the Germicide as it actually appears. A conducting pipe issues from the Germicide, passing down behind the casing and entering the basin, where it terminates. The yellow drops from the pipe indicate the course of the antiseptic solution as it mingles with the water in the basin and trap. The arrows indicate the course taken by the antiseptic *vapor*, issuing from the Germicide *only* when the seat lid is first raised. The words "Please close the lid" embrace all the directions required to operate the appliance. An

omission to do so does not prevent the continuous flow of chloride of zinc, but allows the air in the room to remain unimproved. On entering, the raising of the lid produces the agreeable fumigation of the closet, and the closing of the lid prepares the disinfecting vapor for the next visitor.

Chemical defecation of drains, to be of any real service, must not only proceed automatically, and without any care on the part of those to be benefited, but the chemicals employed must be in *sufficient quantity*. The occasional use of some liquid disinfectant poured into the basin, may be considered of no practical utility. The Germicide could accomplish no *real* good if it contained a *liquid* chemical, because it would be too dilute. Containing, however, solids, in a concentrated form, the water necessary to dissolve the same (and which is not purchased at so much a bottle as is the case when liquid disinfectants are used) is constantly converted into a *liquid* antiseptic. Antiseptics cannot be effectually applied in a homeopathic manner—at least a barrel a month should be employed in closets constantly used. It is evident then that a sufficient quantity can only be applied by a method which uses solids, gradually dissolved by a *continual flow of water*.

The four cases already mentioned, which were found to be beyond the limits of *mechanical* defecation, are entirely controlled by the auxiliary aid of *chemical* defecation as applied by the Germicide system.

1st. THE PASSAGE OF GASES THROUGH THE WATER OF TRAPS and its prevention by the use of a material put into the traps to arrest such passage, was experimentally demonstrated on page 8. The Germicide accomplishes precisely this result, by the constant delivery into the water-closet trap of a solution of metallic salts, possessing the required properties. The trap, then, not only offers a *physical* barrier to the rapid inflow of gases generated in the soil-pipe or sewer, but by the chemical properties imparted arrests and destroys the hurtful elements of such gases by chemical agency.

2. TRAPS ARE NO LONGER CESSPOOLS, as their contents are so influenced by the disinfecting properties imparted that the fermentation of fæcal matter is arrested until it passes on to the sewer. Especially during the night hours, when closets are idle, does the great importance of continuous chemical defecation become manifest. The trapping-water at such times, exposed for several hours, becomes saturated by gaseous absorption, and the material last deposited in the trap has ample time to generate foul gases to vitiate the air of the closet and house. *Especially at night* should we have *fresh air in our homes.*

The antiseptics employed are well known to possess the power to arrest odors arising from fæcal matter kept in bottles for months. It is, however, not the design, in chemical defecation, to prevent permanently odors arising from such matter, but simply so to say pickle them until, by water carriage, the trap has been relieved of its contents. It is just here that a signal misunderstanding of the proper application of disinfection has existed. Its spasmodic or occasional use, while *mitigating* bad odors, has, because not continuous, allowed such odors continually to reappear. It seems surprising that

intelligent persons should so misunderstand disinfection, and think that *occasional* employment can produce *continual* results. Pouring a *concentrated* liquid disinfectant into a water-closet basin is a waste of material, for it is soon washed away. It is the constant employment, *day and night*, of a *dilute* solution, that both theory and practice show to be the desideratum.

" While a thimbleful of water will extinguish a burning match, many gallons might be inadequate to quench the conflagration the match may originate. Many gallons of a purifying fluid would be required to defecate the soil-pipes, receiver, traps, etc., of some city houses, while a small quantity *daily* employed prevents such necessity."

It is thus seen that sewer gas is by no means the only source of house air vitiation—the traps, the receivers in pan closets, and the soil-pipes within our dwellings are constantly emanating gases.

3d. THE EMPTYING OF TRAPS BY EVAPORATION is prevented by the constant and even flow from the Germicide into the basin; and, should they become empty by syphonage, a water-closet temporarily out of use would in a short time have its trap refilled. The importance of keeping the traps full is obvious, and during the summer months, when the water-closet is idle, the constant flow of liquid disinfectants not only prevents the trap from getting empty by evaporation or suction, but also prevents absorption. To return from fresh country air to a house where the atmosphere may be permeated with impurities from drains, etc., and, in time of epidemic, perhaps even with disease germs, is an unwarrantable challenge to nature.

4th. EMANATIONS WITHIN THE CLOSET are, as has been stated, beyond the reach of mechanical defecation. The trap, which is the plumber's "last ditch," and the receiver under the basin and out of sight, sometimes contribute less to the discomfort of the closet than the source under consideration. The first attempt ever made to overcome this traditional, tacitly accepted, and apparently inherent source of discomfort in the water-closet on scientific principles is practically realized in the Germicide system. The difficulty in overcoming this evil arises from the fact that in so doing nothing should be employed possessing a sufficiently strong odor to disguise any bad odor from the water-closet itself. The only consistent way to destroy the emanations in question is to cause them, *when produced*, to come in contact with a disinfectant, *in vapor*,* generated at the same time. Such vapor must not be a perfume, but must have the power *actually to destroy* and not *conceal* the emanations. A *necessary requisite* is that the disinfecting vapor must be generated only when required, and not give off a continuous odor, as would be the case with any volatile disinfectant kept in open vessels.

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* The antiseptic vapor is that of Thymol, which is considered in Europe to be ten times more efficient than Carbolic Acid. As it possesses but little odor, it will no doubt supersede the unpleasant acid now in general use. The Thymoline used in the Germicide is a fluid compound of Oil of Thyme, which undergoes constant oxidation while within the Germicide, which action on the Cymene and Thymene of the Oil of Thyme converts the latter into Thymol, thus increasing the Thymol already existing in oil.

A PAPER READ BEFORE THE N. Y. ACADEMY OF SCIENCES,

ENTITLED, "CHEMICAL DECOMPOSITION INCITED BY A COLD FLUID STRATUM FLOATING ON A WARM LIQUID;" OR A NEW PROCESS FOR PRODUCING CHLORIDE OF ZINC FOR THE GERMICIDE.

DECEMBER 13, 1880, BY DR. H. A. MOTT.

LADIES AND GENTLEMEN—It may seem, at first thought, rather paradoxical to talk of a cold fluid stratum of a given solution, floating on the surface of the same solution, of many degrees higher temperature, but after the momentary shock of the paradox (if a proper explanation can be given) no harm is done.

It is my object, therefore, this evening, to explain this apparent paradox, which has occupied the attention of some of our most distinguished scientists. Dr. Antizell, the well-known patent examiner at Washington, investigated this problem with great care, and frankly acknowledged his inability to explain the phenomenon it presented.

The phenomenon takes place when Zincic Chloride is manufactured by a new process discovered by Professor E. J. Mallett, Jr., which I will briefly describe, and which I believe I have the honor of presenting, for the first time, to a scientific association, and then I will explain the cause of the metathetical change, the cause of the temperature of the body of the solution remaining the same, the cause of the cold fluid stratum floating on the surface of the warm solution, and, finally, wherein lies the industrial value of the process.

For the production of Zincic Chloride by Mallett's process a tank or vat is required of suitable dimensions, having a depth of from six inches or as many feet, in which is introduced a solution of zincic sulphate and sodium chloride in equivalent proportions. The tank is completely filled with the solution or filled sufficiently to cover to about one inch a horizontal connected series of pipes forming a layer of metallic tubing or piping placed near the top of the tank. The piping having about one inch or one inch and a half external diameter. The connected pipes of the series being about one inch under the surface of the solution, are placed close together and extend practically throughout the area of the surface stratum, and they communicate with a reservoir containing a refrigerating liquid, which, by means of a force pump, is driven through the piping. This current through the pipes rapidly reduces the temperature of the stratum to a depth of about ½ of an inch, to an inch, depending upon the diameter of the pipes.

The temperature of this stratum above and below the piping being reduced below 32° F., or 0° C., while the main body of the solution below the stratum remains practically at the normal temperature.

The cool stratum at once incites crystallization and sodic sulphate, containing 10 molecules of water, separates out at the bottom of the tank, leaving a mother liquor, containing Zincic Chloride, which can be siphoned or drawn off, and treated by the usual process.

The cause of the metathetical change is a problem of considerable interest, and, I think, few are acquainted with the fact that such changes can take place.

The changes we are to consider here at first are those which involve decomposition and combination without separation, and then those which involve separation of crystalline compounds.

When two saline salts are dissolved in water a definite amount of metathesis seems always to take place, produced by the mutual interchange of their positive and negative radicals; but there is in ordinary cases no proof that any such change takes place. Still, it is a generally conceded fact that a mixture of four different salts is produced, the proportions depending on the relative strength of their affinities and on the quantities of each present.

A mixture of magnesic sulphate and sodic chloride in solution exists as sodic sulphate, magnesic sulphate, sodic chloride, and magnesic chloride.

$$2\ Mg\ SO_4 + 3\ Na\ Cl + Aq = Mg\ So_4 + Na_2\ So_4 + Mg\ Cl_2 + Na\ Cl.$$

I suppose this change is allowed to take place because the force of cohesion amongst the component particles of the bodies dissolved is balanced by their adhesion to those of the liquid, and the particles of substances in solution being free to move in any direction, easily obey the force of chemical attraction which, of course, is a molecular force, exerting itself when the particles of bodies are within distances indefinitely small.

Besides the reasons just mentioned, differences of solubility, at different temperatures, can produce alternate decomposition or metathetical changes.

In the case of magnesic sulphate and sodic chloride, of the four salts it forms sodic chloride is the least soluble at the boiling point. By concentration (by ebullition) sodic chloride crystallizes out, and as the liquid cools magnesic sulphate crystallizes out. But if the solution is allowed to evaporate spontaneously in the open air at low temperature, sodic sulphate being the least soluble crystallizes out, whilst the readily soluble magnesic chloride remains in solution.

It has also been found* that when a solution containing equivalent quantities of zincic sulphate and sodic chloride is cooled, zincosodic sulphate crystallizes out at $+ 10^0$ C; but at O^0 pure sodic sulphate separates while the soluble zincic chloride remains in solution.

Malagute † has also shown that a metathetical change takes place when one equivalent of zincic chloride in an aqueous solution is mixed with a solution of an equivalent of potassic sulphate—0.290 of it is decomposed to zincic sulphate, which may be precipitated by adding alcohol, while 0.71 of it remains unchanged. It therefore follows that when zincic sulphate and sodic chloride are dissolved in water together, the solution

* Watts Dic. Chem,, vol. v, p 1069 (1869).

† Ann. Ch. et Phys., 1853 (3) 37–20, 3.

contains a mixture of zincic sulphate, sodic sulphate, zincic chloride, and sodic chloride.

$$2\,Zn\,SO_4 + 3\,Na\,Cl + Aq = Zn\,SO_4 + Na_2\,SO_4 + Zn\,Cl_2 + Na\,Cl + Aq.$$

If I represent the production of zincic chloride as manufactured by Mallett's process by the usual formula we will have:

At Wt.—64.9, 31.98,15.96, 22.99 35.37 (Latest Determ.)

$$\underset{N}{Z}^{+//}\,(\overline{S}^{vi}O_4^{//})^{//} + 2\underset{A}{N}^{+/}\,\overline{Cl}^{/} = \underset{N}{Z}^{+//}\,\overline{Cl}_2^{/} + \underset{A_2}{N}^{+/}(\overline{S}^{vi}O_4^{//})^{//}$$

$$64.9 \quad 95.82 \quad + 45.98 \quad 70.74 = 64.9 \quad 70.74 + 45.98 \quad 95.82$$

$$160.72 \quad + \quad 116.72 \quad = \quad 135.64 \quad + \quad 141.80$$

$$277.44 \quad = \quad 277.44$$

From this formula it will be seen that the metathetical change, whilst depending somewhat on the relative strength of the affinities of the radicals, and also on the quantities of each present, depends more in Mallett's process on the fact that differences of solubility at different temperatures can produce a metathetical change.

One fact will be noticed, however, that on the left-hand side of the equation we find the less positive zinc (in comparison to sodium) united to the more negative sulphur and oxygen (in comparison to chlorine), but on the other side of the equation we observe that the change which has taken place has united the more positive element to the more negative elements, and the less positive element to the less negative element. In other words we find the more positive metal sodium united to the more negative sulphur and oxygen, whilst the less positive zinc is united to the less negative chlorine.

It will be necessary now to consider the separation of the crystalline compound, which is accompanied by a considerable rise of temperature.

According to Thompson's thermo-chemical investigations, the dissolution or separation of sodic sulphate from its water solutions at 18° C, is accompanied with the following results:

	Number of molecules taken up when dissolved in water.	Number of units of heat absorbed per molecule.
$Na_2\,SO_4\,10\,H_2\,O$	50	17,460
	100	18,130
	200	18,550
	400	18,760
	600	18,810
$Na_2\,SO_4$	400	60

From this it will be observed that when decasodic sulphate crystallizes from its solution, about 18,500 units of heat per molecule is given to the solution.

Of the four salts we have just considered zincic sulphate is the most insoluble at 0° C., and zincic chloride the most soluble at that temperature. This will be seen to be a very important factor in the explanation.

It may be stated as a fact that on concentrating a mixed solution by evaporation, the salt which is least soluble at the particular temperature employed is that which is first formed—the case, however, in manufacturing zincic chloride by the new process is somewhat different, as the separation of sodic sulphate is not accomplished by the aid of concentration or evaporation. The solution of the zincic sulphate and sodic chloride in equivalent proportions is made at the ordinary temperature, and the separation of the sodic sulphate is only incited by the cold layer floating on the surface of the solution, for it is only about 0° C. that pure sodic sulphate will crystallize out, as at +10° C., zinco-sodic sulphate crystallizes out in its stead. This has been proved by cooling the whole solution. It therefore follows that the separation of the deca-sodic sulphate is incited by the cold stratum, as a warm stratum would not accomplish the result.

We have now to show why the body of the solution remains at about the normal temperature, not losing heat, from the influence of the cold stratum floating on its surface. This problem, I think, can be very readily answered. As I stated before, when deca-sodic sulphate crystallizes from its solution, about 18,500 units of heat per molecule is absorbed by the solution, which is quite sufficient to keep the temperature of the body of solution below the cold layer warm, and prevent it from losing heat, and thereby reducing its temperature by the influence of the cold stratum. Of course, after all the sodic sulphate has crystallized out, and no further change takes place, the body of the solution not only should but does become in time of one uniform temperature.

The cause of the cold fluid stratum floating on the surface of the warm solution I have now to explain. It is a well-established fact that when the temperature of a solution is reduced, its specific gravity becomes much greater. From this, if from no other reason, should the cold layer or stratum, as soon as formed, settle down or tend to do so, until the body of the solution and itself becomes of a uniform temperature. This is found to be the case—the cold stratum which can be seen floating on the warm solution is constantly changing, new solution is constantly taking its place, so long as there is sodic sulphate to crystallize out; and the reason that the body of the solution does not materially change in temperature is because the amount of heat given out to the solution by the sodic sulphate in the act of crystallization is just sufficient in this case to neutralize the tendency of the cold solution to reduce its temperature. That the cold stratum is constantly changing is supported by the fact that only at about 0° C. can deca-sodic sulphate be made to crystallize out; such crystallization can only be incited by reducing the whole body of the solution to 0°, or by reducing a stratum to 0° C. It is evident that, if the stratum was not continually being replenished by the solution, only the sodic sulphate in the stratum could crystallize out; but this is not found to be the case, for the whole solution does in a short time practically surrender up all of its sodic sulphate in a crystalline form.

The cold stratum therefore arises from the withdrawal of heat from the solution by the refrigerating liquid, and would in fact not be a defined stratum, but the whole

solution, if it were not for the counteracting units of heat liberated by the sodic sulphate in the act of crystallization, which are sufficient to keep the solution warm or at the normal temperature to within an inch or fraction of an inch of the tubes, thus defining the stratum.

The value of the process lies in the fact that, as only part of the solution has to be cooled instead of the whole, less time is required to accomplish it, as also less refrigerating material is consumed, two elements which figure importantly in the cost of manufacture. There can be no question but that the process discovered by Mallett will open a new era in the production of numerous salts which find application in commerce, and thereby reduce their present cost of manufacture.